ARTICLE IV.

THOUGHTS ON THE INFLUENCE OF ETHER IN THE SOLAR SYSTEM. ITS RELATIONS TO THE ZODIACAL LIGHT, COMETS, THE SEASONS, AND PERIODICAL SHOOTING STARS.

BY ALEXANDER WILCOCKS, M.D.

Read May 20, 1864.

In undertaking the investigation of a subject whose history runs back into remote antiquity, one is met by obstacles which do not interfere with an inquiry into a more recent theme.

These difficulties lie chiefly in two of the customs of Eastern nations, viz., the mingling together of fact and fable, and the confounding of two ideas under one name.

The question might be pertinently asked, How are we concerned in what the Hindoos or the Greeks thought about ether? The answer appears practically in the fact, that the minds of some of the most eminent astronomers of the day have been biased by the views of these ancient peoples.

It is impossible for us to determine who or what first gave rise to the idea of the existence of such a fluid as ether; it was probably akin to that which avers that "Nature abhors a vacuum." If so, the conjecture, true though it be, merits no higher consideration than that of a *sublime guess.*

"Among the natural philosophers of India, ether (*âkâ'sa*) was regarded as belonging to the *pantschatâ*, or five elements, and was supposed to be a fluid of infinite subtlety, pervading the whole universe, and constituting the medium of exciting life as well as of propagating sound."

"In the dogmas of the Ionic philosophy of Anaxagoras and Empedocles, this ether (ἀιθήρ) differed wholly from the actual (denser) vapor charged (ἀήρ) which surrounds the earth, and probably extends as far as the moon." It was of a "fiery nature, a brightly beaming, pure fire air, of great subtlety and eternal serenity."

"The natural philosophy of Aristotle further teaches that the ethereal substance penetrates all the living organisms of the earth, both plants and animals; that it becomes in these the principle of vital heat, the very germ of a psychical principle, which, uninfluenced by the body, stimulates men to independent activity."*

* Cosmos, vol. iii, chap. 1.

It is scarcely necessary to remark that the ether by whose agency it is proposed to explain the interesting phenomena alluded to in the title of this essay, is not a fluid possessed of the fanciful properties ascribed to it by the ancients. My only purpose in dwelling upon these is to show, as I shall do presently, how such ideas have poisoned the minds of modern philosophers.

To Professor Encke is the learned world indebted, for pointing out the first rational evidence of the existence of an ethereal medium, in the continually diminishing period of the comet which bears his name.

By its influence upon Encke's comet, the ether shows itself to be possessed of two of the properties of aeriform bodies, viz., inertia and impenetrability. It would not be advancing too far, nor too fast into the land of speculation, to endow this fluid also with gravity, elasticity, and expansibility by heat.

The possession of the properties of gravity and elasticity leads to the conclusion that the particles of ether must be collected into denser masses in the vicinity of the central body of our system, than in regions remote from the sun; and the inquiry at once suggests itself, what law governs the density of the ether in the different parts of the solar system?

In the terrestrial atmosphere, where the influence of a varying distance from the centre of attraction is too small to be appreciated, and where the increase of the density near the earth's surface is due almost solely to the superposition of the particles of air, we find the rate of diminution of density to be in the duplicate ratio of the altitude.

In the interplanetary spaces, the laws which determine the rate of diminution of the density of the ether are more complicated.

The ethereal pressure at any given point in the solar system, will depend not only upon the *quantity* of ether beyond it, but also upon the *power* which the *sun* has to attract that which is beyond the point in question.

Now, either of these causes acting alone should fix the rate of diminution at the square of the distance from the sun. As both of them act together, a legitimate inference should be, that the density of the ether decreases as the fourth power of the distance from the sun's centre.

In considering the subject of ether, we must endeavor to guard ourselves against certain errors into which our daily intercourse with matter may lead us. We see, for example, the collision of heavy bodies, and, as a result, the production of fragments whose weight and hardness we can estimate with our hands. These are phenomena which so vividly impress our senses, that we are apt to ignore the possible existence of matter in a form which, to our sight and touch, may be inappreciable.

It is this form of matter that now concerns us, and to give a faint idea of its tenuity,

let me say that physicists have estimated that beyond the region of our atmosphere there is no matter as dense as the contents of an exhausted receiver.

While engaged upon this subject, let us put aside the gross ideas which attach to matter upon the surface of our planet, let us view it as we know it exists in the celestial spaces, and let us be prepared to find in the movements of the ether when impelled by the tremendous energies which I shall presently invoke, a rapidity, which knows no parallel among the ponderable agents with which our senses bring us into contact.

We must now study some of the facts which the observations of eminent astronomers have taught us, concerning the governing orb of our system.

The sun is known to have an opaque nucleus, surrounded by an atmosphere of vast but unknown height, one stratum of which is luminous, and has received the name of *photosphere.* Certain appearances resembling luminous clouds, seen round the disc of the moon during the time of a total eclipse of the sun, lead to the belief that the sun's atmosphere extends far above the luminous stratum. In that elevated region of the sun's gaseous envelope, there are strong indications of imperfect transparency.

A close examination of the spots upon the sun's disc, teaches us that it revolves upon an axis, which is inclined to the plane of the ecliptic.

The determination of the period of the sun's rotation, with the amount and direction of the inclination of its axis, is among the difficult problems of astronomy. Different results have been obtained by different observers. I shall rely upon the accuracy of those furnished by M. Arago for these data, which are of vital importance to the theory I am about to offer.

According to the authority cited, the sun's axial rotation is accomplished in 25.5 days. The solar equator is inclined to the ecliptic about 7 degrees; and the line of nodes is in longitudes 75° and 255°.* Let me add that the north pole of the sun is inclined toward longitude 345°.

An interesting feature in the sun's constitution, the study of which has occupied the minds of Henry, Nervander, Carlini, Secchi, and others, is the difference in temperature of different parts of the solar surface. The observations of Secchi have produced more definite results than those of his colaborers in this field of research.

Secchi made observations upon the sun on the 20th, 21st, and 22d March, 1852, which were unsatisfactory in several particulars. At that time of the year the sun's equator appears at its extreme angular distance from the plane of the ecliptic. The observations were continued only three days, when twenty-seven were requisite for valuable results; and instead of being made in the line of the sun's axis, the line of a circle of declination was chosen, which on the 21st March lies at an angle of 25° 15′ 57″ with the former.

* Astronomie Populaire, vol. ii, pp. 86 and 87.

Secchi was more happy in the choice of a time for observing the sun's temperature in the year 1855.* The 8th of June was fixed upon, as the sun is then near that part of the heavens where the plane of its equator intersects the ecliptic.

The latter observations were undertaken with the view of determining the effect of the sun's atmosphere in diminishing the power of its rays. They produced no new facts in the matter of the relative temperature of different parts of the solar surface.

From an analysis of Secchi's observations on the sun in 1852, M. Arago presents the following summary: Different points of the sun's surface have different temperatures. The rays from the centre of the disc produce most heat, and from that point the heat diminishes towards the margin. At equal distances from the centre of the disc, the polar regions have a lower temperature than those about the equator; and the two hemispheres separated by the equator have unequal temperatures. The spots produce a diminished temperature, but the faculæ do not cause a sensible increase of heat.†

From Secchi's observations in 1852, Prof. Littrow concludes that the intensity of radiation of heat of different points in the sun's disc is different, not only in consequence of the absorption by the sun's atmosphere, but also because every part of the sun's surface really has its peculiar temperature. On the 20th, 21st, and 22d March, the greatest intensity was found 3′ north of the sun's centre. The sun's equator was at the time 2.6′ north of the centre. The northern and southern hemispheres have unequal temperatures, as well as the hemispheres, divided by a heliocentric circle of declination.‡

Having collated the data relating to the rotation of the sun, the position of its axis, and the heat of its surface; having also drawn such conclusions regarding the density and other properties of the ether as observation and analogy have appeared to sanction, let us endeavor to determine what conditions are induced by the sun in the great ethereal ocean of which it is the centre.

A ponderable elastic fluid of imperfect transparency, resting upon the surface of an incandescent sphere, could not by any possibility remain in a state of rest.

If the sphere were at rest, and its whole surface of a uniform temperature, there should be upon every part of it alternate ascending and descending currents of the elastic medium; but, if any zone were permanently of a higher temperature than the rest of the surface, then ascending currents should be permanently established upon such part of the sphere, and descending currents upon those portions where the temperature was of a lower grade.

We have learned that the parts of the sun's surface which have the highest temperature, are the equatorial regions, and that those having the lowest are the polar regions;

* Astronomische Nachrichten, No. 1230.

† Astronomie Populaire, vol. ii, p. 173.

‡ Wunder des Himmels, appendix, p. 818.

we are, therefore, led to the conclusions, that from the equatorial zone there is a permanent ascending current of ether, and that upon the two polar regions there are descending currents.

If the sun's surface *had* a uniform temperature, its axial rotation should bring about the same conditions as those I have shown to result from the peculiar distribution of its heat. The fluid resting upon the revolving sphere, its lowest stratum should partake of the motion of the sphere. The centrifugal force resulting from the circular motion should cause an accumulation of fluid upon the equatorial zone, and as a result a rarefied condition of the fluid in those parts where the causes of the excess existed in the *smallest* degree. The centrifugal force is null at the poles; therefore, upon the polar regions should be thrown the supply of cold fluid to preserve the equilibrium.

As particles of fluid moving from opposite points towards a centre, always take the direction of a circle round that centre, we are led to the belief that the ether descends upon the polar regions in the form of vortices.

Thus do we find in the constitution of the sun, two distinct causes, the one depending on heat, the other on motion, which produce in the ethereal medium a double circulation over the solar surface, and through the region of the planets.

Let us trace the course of these stupendous currents. Towards the poles of the sun, as the seats of the lowest heat and the least motion, the ether is drawn from the regions of space, and descends upon the poles and the adjacent parts in the vortical form. Thence it is wafted by the double set of causes towards the equator, whence it is forced out into the region of the planets, in a mass whose form closely resembles a perfectly flat plate, the plane of which nearly coincides with that of the sun's equator.

With regard to the energy with which these movements in the ether are effected, our approaches to a conjecture must be based upon a comparison between the causes which produce currents in the earth's atmosphere, and those brought into play in the grand ethereal circulation.

In carrying out this parallel, we must fix our attention successively upon each of the causes known to be concerned in the production of motion in the terrestrial atmosphere, and then upon the corresponding one, believed to influence the movement of the ether.

By collating the results of these several comparisons, we may obtain the basis for a conjecture as to the velocity of the ethereal currents.

The immediate cause of all motion in our atmosphere is the earth's gravitating power, and by an analogous influence the sun occasions the ethereal circulation. The sun's energy in this respect is *cæteris paribus* directly as its mass. The mass of the sun is 354,936* times that of the earth. Here we have the first element of our comparison.

* Herschel.

The next point to be considered is the difference of heat in different parts of the earth, in comparison with the temperature of space contrasted with that of the sun's surface.

The heat of the sun's surface is estimated at 300,000 times that produced by its rays upon the surface of our planet. If we assume the minimum temperature of our atmosphere to be the same as that of space, we should have the measure of the sun's power to expand the ether, as compared with the influence of its rays upon our atmosphere, at 300,000.

This is the second element of our comparison.

The last I shall offer is the difference between the height of the earth's atmosphere, and the depth of the ethereal ocean.

The earth's atmosphere is supposed to extend to the distance of from 40 to 200 miles above its surface. We have no reason to suppose the ether has a limit within that of the solar system.

If the velocity of the ether depend upon these agencies, it certainly defies computation. But we may safely believe that it surpasses that of all known ponderable fluids; and can be likened, in the vicinity of the sun, only to that of light.

When an image of the sun is thrown upon a sheet of white paper, it may be observed that the borders of the disc are much less luminous than the centre. This may be explained by the *refractive* or the *absorptive* power of the sun's atmosphere.

When, during an eclipse of the sun, the moon is centrally over the former, a ring or corona of light is seen fading gradually away. This phenomenon cannot be explained without admitting in the sun's atmosphere the existence of some matter capable of reflecting light.

Various hypotheses have been offered as to the origin of this reflecting matter. Its existence alone concerns us; without it, a link in the chain of reasoning would be wanting, which would defeat our aims; for unless the ether contained matter which could arrest the sun's rays, it would be impossible to establish by *à priori* reasoning, the existence of currents.*

A mass of ether ascending from the equatorial region of the sun, and containing matter capable of reflecting light, should certainly make an impression upon our visual organs, whenever the absence of the sun favored its being seen. It therefore becomes a question of much interest, what form should be given by perspective to such an object, as seen from the earth.

The approximate form which I have deduced for the ascending current of ether, is that

* It will be observed that I have used the terms ether and sun's atmosphere, almost as synonymes. Until we learn in what the constitutions of these fluids differ, or where is the dividing line between them, the confounding of their names can produce no evil results.

of a flat plate, whose plane coincides with the sun's equator. But inasmuch as the maximum heat upon the sun's surface was found a little north of the equator, the form of the ascending current of ether should be rather that of *a hollow, frustated cone*, whose sides, if produced, would form an exceedingly obtuse angle at the sun's centre.

If we suppose that the functions of receiving cold ether from the regions of space, and of forcing it again from the sun, divide the surface of that orb into equal parts, the zone from which the current ascends must have a breadth of 30° on each side of the sun's equator. Such a division of the solar surface is, however, inadmissible, for the ether descending upon the poles should have its volume so enormously increased by the sun's heat, that the area from which it escaped into space, must have a great preponderance over the regions where the fluid arrives in its condensed state. We may, therefore, conclude that the regions upon which the ether descends are comparatively small.

The ether which ascends from the regions remote from the equator, must have initial directions deviating much from the plane of that circle; this should make the thickness of the ascending current, near its origin, as great, or greater than the diameter of the sun.

But this thickness we cannot suppose could continue; for, as the ether advances into the region of the planets, its expansion should be counterbalanced by a loss of thickness. The immediate cause of the flattening being the pressure of the cold ether on the two sides of the plate.

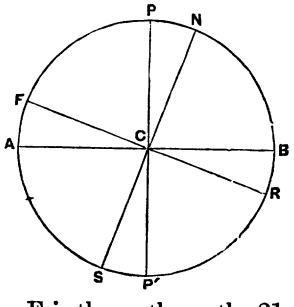
With the flattening of the ascending current, we may look for the effect of the position of the line of maximum heat upon the sun's surface.

An analysis of Secchi's observations leads to the conclusion that the line of greatest heat is at the distance of 1° 29′ 06″ north of the sun's equator.*

* The purpose of the following demonstrations is threefold. Firstly, to show the relations which the axis and equator of the sun bear to the ecliptic. Secondly, to picture the appearance which the sun presented to Secchi at the time of his observations. Lastly, by trigonometrical measurement to determine, with Secchi's observations as data, the position of the line of maximum heat upon the sun's surface, with reference to the solar equator.

Fig. 1 is designed to show the positions of the equator and axis of the sun in relation to the ecliptic. A B represents the plane of the ecliptic, P P′ its poles. The circle is the sun's disc, F R its equator, and N S its axis.

FIG. I.



The time of the year when the parts appear in these relations, is about the 6th of June. N C P is the angle by which the sun's axis is inclined to the poles of the ecliptic, about 7°.

As the earth revolves in its orbit, the sun's axis apparently describes a circle about the poles of the ecliptic.

All this will appear more clear by viewing the solar system from a point in space opposite its northern face.

In Fig. 2, the smaller circle represents the sun; the larger one the earth's orbit. E is the earth, on the 21st March. P is the pole of the ecliptic, N the north pole of the sun, inclining towards longitude 345°. If the

If the form of the mass of heated ether be determined by the causes I have cited, it earth were at D, the parts would appear as described in figure 1. If the earth were at F (the position occupied by our planet about the 5th of March), the sun's axis and the poles of the ecliptic would appear to coincide, but the earth being at E, they deviate by O N, which is the sine of an arc of 15° whose radius is 7°.

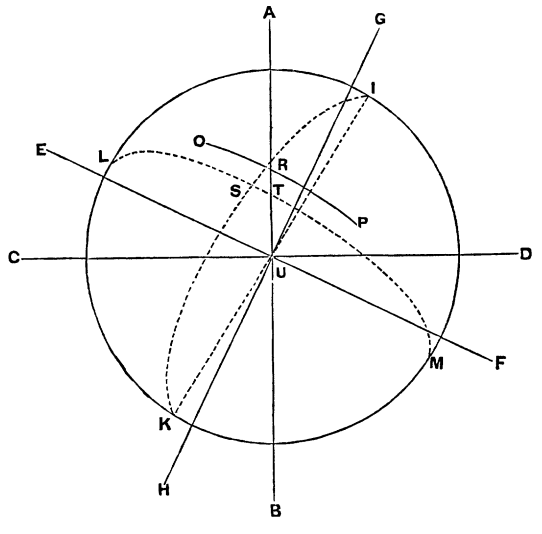
Let us ascertain the value of this deviation in degrees of the sun's surface.

Radius : Sin. 15° : : Sin. 7° : Sin. 1° 48′ 27″.

We are now prepared to picture to ourselves the sun as it appeared to Secchi on the 21st March, 1852. We have ascertained that the apparent inclination of its axis to the poles of the ecliptic, was 1° 48′ 27″, and we have the data for determining the relations of all its parts to the great circles which are the landmarks of astronomy.

In Fig. 3, the circle represents the sun's disc. The line A B is a circle of declination, C D is the equinoctial line. E F is the ecliptic. G H, the poles of the ecliptic. I K, the sun's axis. L S T M, its equator, and O R P, the line of maximum heat, which Secchi observed on the 20th, 21st, and 22d March.

FIG. 3.



My purpose is to ascertain the measure of an arc of the sun's surface R S, embraced between the equator and the line of maximum heat.

On the 21st March, the angle A U G, or that embraced between a circle of declination and the poles of the ecliptic, is 23° 27′ 30″.

We have ascertained that the angle G U I, or the apparent deviation of the sun's axis from the poles of the ecliptic on the day named, was 1° 48′ 27″. By adding these together, we shall have 25° 15′ 57″, or the angle embraced between the sun's axis and a circle of declination.

Secchi informs us that when he made his observations, the sun's equator was 2.6′ north of the centre of the disc. In Fig. 3, this is represented by U T. He found the point of maximum heat to be 3′ north of the centre of the disc, U R in the figure.

On the 21st March, the sun's semi-diameter is 16′ 4.6″. This is the radius of the arcs of which Secchi has furnished us with the sines.

In our investigation we require the measures of these arcs, and their difference in degrees of the sun's surface.

Arc U T.

Sin. 16′ 4.6″ : Sin. 2′ 36″ : : Radius : Sin. 9° 7′ 51″.

Arc U R.

Sin. 16′ 4.6″ : 3′ : : Radius : Sin. 10° 45′ 23″.

10° 45′ 23″—9° 7′ 51″ = 1° 38′ 32″.

We have now ascertained the measure of the arc T R, which will enable us to attain our end; the measure of the arc S R embraced between the sun's equator and the line of maximum heat.

T R is a part of A B, the circle of declination in which Secchi made his observations. We have ascertained that it is inclined to the sun's axis 25° 15′ 57″. The angle which it forms with the solar equator is the complement of this, or 64° 44′ 03″. The last is the measure of the angle R T S.

Arc S R.

Radius : Sin. 1° 38′ 32″ : : Sin. 64° 44′ 03″ : Sin. 1° 29′ 06″.

Fig. 2.

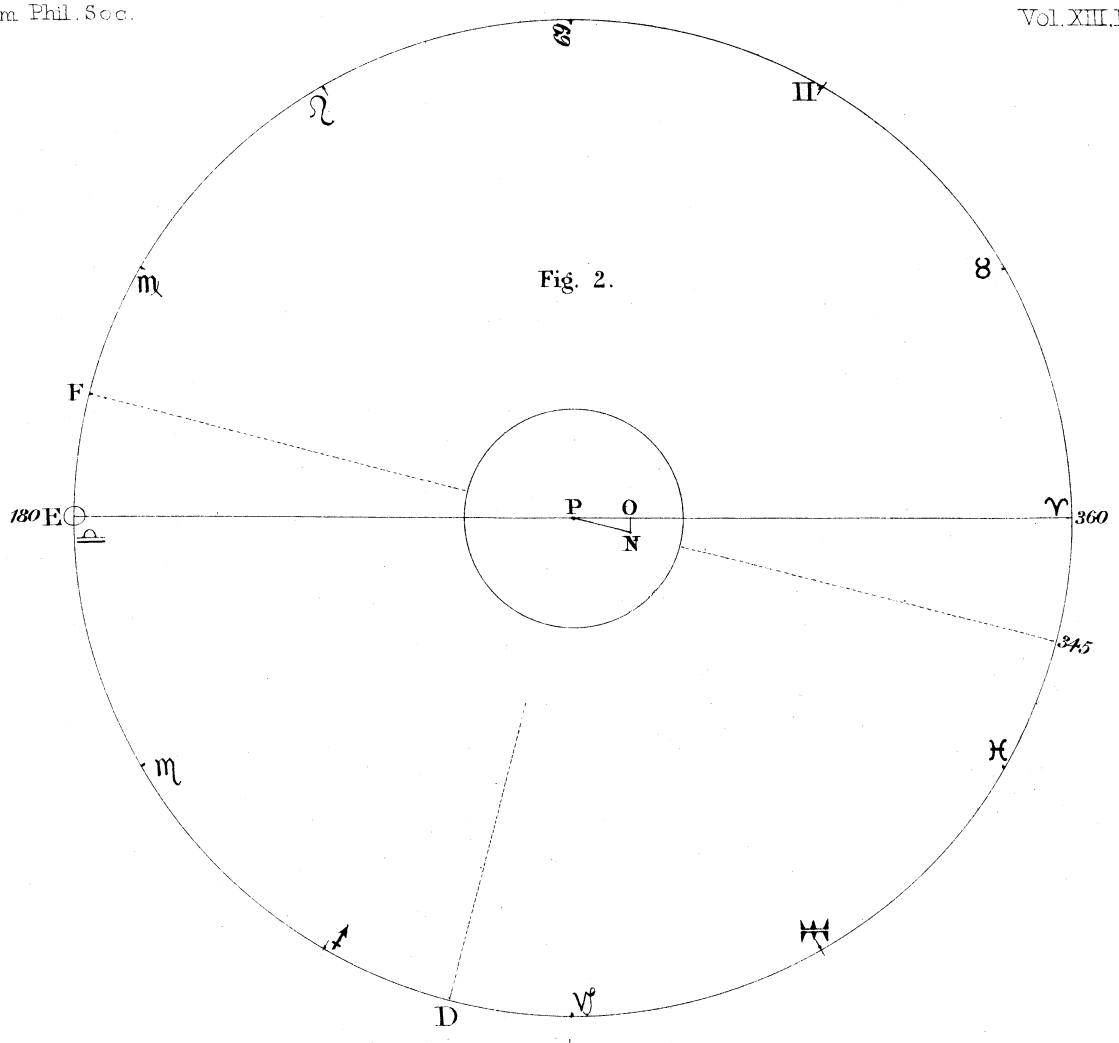

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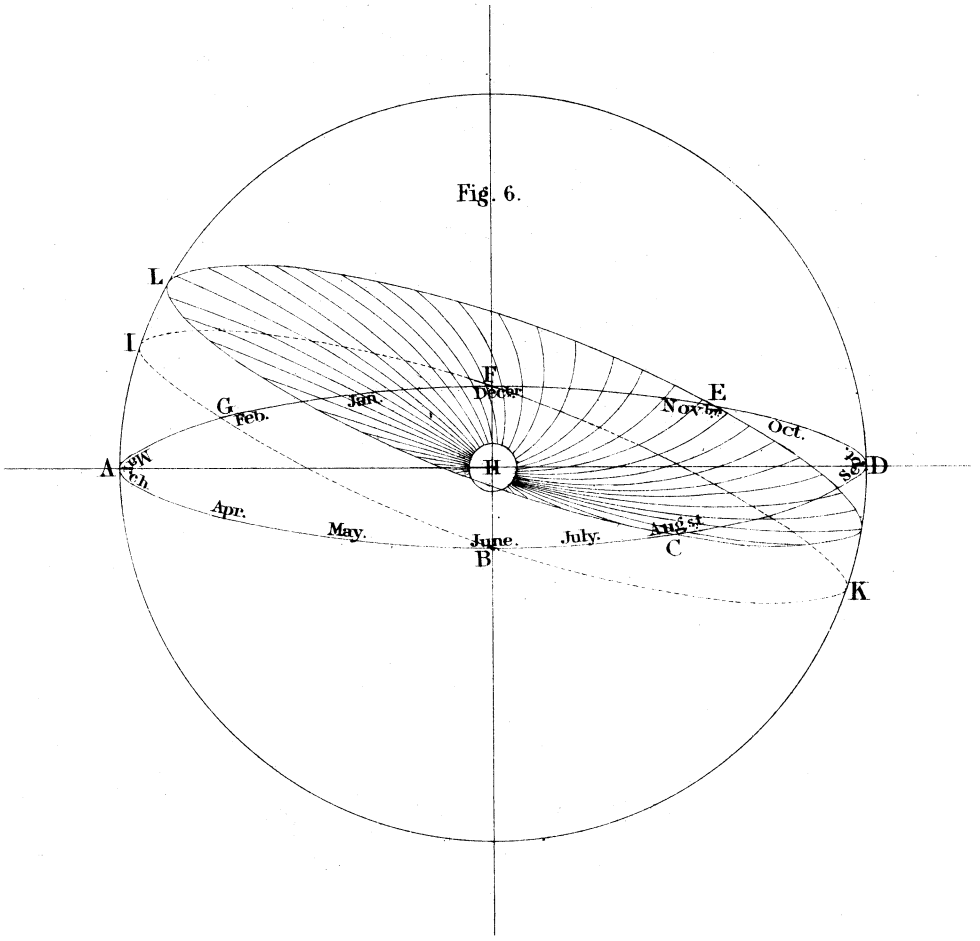
Fig. 6.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justifies the description already given to it, viz., a huge plate, whose sides incline a little from the plane of the sun's equator, so as to give it the character of a hollow cone; the sun's centre occupying the apex of the cone.

Now, how should such a figure appear to an inhabitant of our planet? The earth can never be much removed from the plane of the sun's equator, nor from the body of this mass of heated ether. The mass being seen very obliquely, should have the appearance of a great spindle, whose long axis lies a little north of the plane of the sun's equator. If the current of ether carry reflecting matter as far as, or beyond the orbit of the earth, the spindle should extend 90° or more from the sun.

As the earth's orbit is most distant from the plane of the sun's equator, at the points passed by the planet in March and September, the spindle should, at those seasons, have the greatest breadth. More particularly in March, because the earth is then to the south, and the mass to the north of the plane of the sun's equator. While in September the mass is between the earth and the plane of the sun's equator.*

It is not possible to allow our thoughts to pursue this train, without finding that our minds rest upon the *Zodiacal light* as the evidence of the truth of our reflections.

The zodiacal light in our latitude is seen after sunset in the months of March, April, and May, and before sunrise during the opposite season of the year. It extends along the zodiac, and accompanies the sun in its annual course through the heavens.

It has the form of an ellipse or elongated spindle. The dimensions of the light are variable, its long axis, which coincides nearly with the plane of the sun's equator, extending, according to different observers, from forty to one hundred degrees from the sun. The breadth of its base varies from eight to thirty degrees. It does not efface the light of the smallest stars.

Cassini, one of the earliest observers of the phenomenon, thought the mass of light was not divided equally by the ecliptic; the greater portion being to the north of that great circle. This fact has been confirmed by the observations of Fatio de Duillier, made at Geneva, in 1685 and 1686.†

From observations made at Paris and Geneva, it is established that the zodiacal light has not always the same intensity; it varies from year to year, and even within the limits of a few days.

Among the speculations into the cause of the zodiacal light by the astronomers of the seventeenth and eighteenth centuries, we find very discordant views entertained by the same individuals.

J. D. Cassini conceived that the zodiacal light was a nebulous ring surrounding the sun. He believed that the ring contained small planetary bodies.‡ He admitted at another

* See Fig. 6. † Astronomie Populaire, vol. ii, p. 186. ‡ Cosmos, vol. i, p. 141.

time that the sun might dart matter in the plane of its equator, as far as the orbit of Venus; and that the light reflected from this matter was the cause of the phenomenon.

He suspected, too, that there was a sympathy between the appearance of spots upon the sun's surface and the changes in the zodiacal light.*

Euler was of opinion that the matter which produced the zodiacal light did not extend to the sun, but surrounded it at a certain distance, in the form of a ring.† He is also the author of an essay in the Memoires of the Academy of Berlin,‡ in which the phenomenon is ascribed to the prodigious extension of the sun's atmosphere in the equatorial region; this extension being caused by the impulsion of the solar rays.

M. Arago remarks, it is really strange that so decided a partisan of the undulatory theory of light, so ardent an opponent of the Newtonian doctrine of emission, should give so active a role to the impellent power of the sun's rays.§

The ring hypothesis has been adopted by Schubert, Poisson, and Humboldt; the last considers that the ring is much compressed, and lies between the orbits of Venus and Mars.‖

Olbers believed that the matter composing the zodiacal light extends all the way to the sun, and that the light seen round that body during a total eclipse, is caused by the portion of the matter in that vicinity.¶

These views of Olbers are entirely consistent with the conditions I have been endeavoring to establish; they would have been more interesting, had he advanced some theory to sustain the matter of the zodiacal light in the position which he supposed it to occupy.

La Place entertained views upon the subject of the zodiacal light which were a part of his grand scheme known as the *Nebular hypothesis.* He believed that after the denser parts of the nebula had been consolidated into the sun and planets, there remained a subtile portion, whose atoms revolved round the sun with velocities proportioned to their distances.**

Dr. Young supposed that the phenomenon was caused by the refraction of the sun's light in the earth's atmosphere. But M. Arago asks, why, if this be the cause, should the light be oblique to the horizon.

One of the most modern hypotheses upon this subject, is that of our countryman, the late Professor Olmstead, of Yale College. He conceived that a nebulous body revolves round the sun in an orbit of considerable excentricity, and in a period of six months. The aphelion distance of the nebula he supposed to be equal to the radius of the earth's orbit. On the 13th November he believed the earth and the nebula to pass that point,

* Astronomie Populaire, vol. ii, p. 188.
† Op. citat., vol. ii, p. 183.
‡ Vol. ii, 1748.
§ Astronomie Populaire, vol. ii, p. 190.
‖ Cosmos, vol. i, p. 141.
¶ Ib., vol. i, p. 143.
** Astronomie Populaire, vol. ii, p. 191.

and to remain in proximity to each other about eight hours. By this scheme Professor Olmstead undertook to account not only for the phenomenon under consideration, but also for the shooting stars of the 13th November.* This hypothesis has been adopted by M. Biot.

Another hypothesis of American origin, is that of the Rev. George Jones, Chaplain U. S. Navy. This gentleman, during a voyage to Japan, in the frigate Mississippi, had ample opportunities to examine the zodiacal light between the tropics. Observing that the phenomenon was visible until midnight, not only in the west, but also in the east, he drew the conclusion that the earth was surrounded by a nebulous ring within the orbit of the moon. He also holds the opinion that the moon, by her light, occasionally produces the zodiacal phenomenon.†

Let us examine critically into the competency of some of these hypotheses to explain the cause of the zodiacal light.

In this attempt we must be guided in a great measure by the laws of perspective, which, from the antiquity of the arts of designing and painting, are more thoroughly explored and practically understood than those of almost any other science.

The conjecture most in vogue to explain this phenomenon, is that of a nebulous ring between the orbits of Venus and Mars. Such a ring must be either *equidistant* from the sun with the earth's orbit, *within*, or *beyond* it.

Let us suppose first, that it is *equidistant* with the earth's orbit, that our planet moves through the heart of the ring, as a string is passed through a circle of beads.

Our observer shall be stationed upon the equator at sunset, on the 21st March. If he should raise his eyes towards the zenith, and fix them upon a point 23° 28′ north of the same, he would be looking towards that part of space which the earth had just left. He would, therefore, look into the substance of the ring. The reflection of the sun's light should cause a visible brightness in that part of the heavens, which should fade towards the horizon; besides which, there should be a prolongation of light extending from the point in question towards the western horizon, decreasing in width, but not in brilliancy, to the latter. The cause of this prolongation of light would be the part of the ring occupying the quadrant of the earth's orbit which had been last passed over.

As the night passed on, our observer would find that the brilliant spot near his zenith was sinking towards the west, and at midnight had set. If at this moment he should turn his eyes to the east, he would discover a similar bright spot rising; he would then be looking again into the substance of the ring, but towards the opposite point of space, that, in fact, towards which the earth was moving. As this spot rose towards the zenith, he would

* American Journal of Science and Art, vol. xxix, p. 376.

† Astronomical Journal, Cambridge, Mass., No. 84, May 26, 1855.

discover another prolongation of light extending to the eastern horizon, and caused by the part of the ring lying in the quadrant of the earth's orbit, through which it was about to pass. The bright spot would finally reach a point 23° 28′ south of the zenith, when the sun would rise.

These are appearances which must of necessity ensue in the existence of the conditions above proposed. They never having been observed, proves that the conditions do not exist. There is no ring equidistant with the earth from the sun, and through which our planet moves.

Let us next suppose that the nebulous ring is *within* the earth's orbit, and to carry out the scheme of those who favor the hypothesis, let the plane of the ring coincide with the sun's equator. A ring so placed could never appear to extend ninety degrees from the sun, which distance the zodiacal light often exceeds. Further, in the months of March and September, when the earth is at its maximum distance from the plane of the sun's equator, a dark triangular space should be seen between the ring and the sun, especially if, as Von Humboldt surmises, the ring is much compressed.

So far from such an appearance being observed, the portion of the zodiacal light near the sun is the brightest. These two objections are sufficient to dispose of this conjecture.

The last branch of the ring hypothesis is, that the ring is *beyond* the earth's orbit. In this case the brightness should extend from the point of the horizon where the sun had disappeared, through all the visible signs of the zodiac to the eastern horizon. The part having the greatest brightness should be nearest the zenith at midnight, because the particles of the ring in that position would be in the category of full moons, presenting the whole of their illuminated surfaces to the earth.

Has such an appearance ever been seen? If not, the conditions which should occasion it do not exist.

With regard to Cassini's idea of the sun's power to *dart* matter into space in the plane of its equator, do not let it be confounded with the theory I am endeavoring to establish, of the ascent of a current of ether in the equatorial region, from the cause of its lessened specific gravity.

The sun's power to dart matter into space, is purely conjectural.

With the limited amount of our knowledge of nebulæ, it would be an ungrateful task to argue either for or against the competency of Professor Olmstead's hypothesis, to explain the cause of the zodiacal light. Were this point conceded, there are other objections to it which should render its adoption by reasoning people an impossibility.

The existence of the nebulous body, of which he furnishes us not only with the periodic time, but also with the perihelion and aphelion distances, is an idea for the truth of which there is not a shadow of evidence.

The doctrine of probabilities satisfies me that if a nebulous body did revolve round the sun in the space within the earth's orbit, the chances of its performing its revolutions in exactly half a year, and meeting the earth annually on the 13th of November, would be precisely one to infinity.

It is true the arcana of astronomy furnish us with some remarkable coincidences, not only in the simple periods, but also in the grand cycles of the heavenly bodies. I shall have occasion in the progress of this essay to point out one of these coincidences not heretofore noticed, having an important bearing upon our subject, and which, in respect of exactitude, is almost without a parallel in the annals of the science. But any hypothesis, based upon an *imaginary* coincidence in period of bodies independent of each other, staggers under a load which will certainly crush it.

We have one more hypothesis to examine, that of the nebulous ring round the earth, proposed by the Rev. George Jones, U. S. N. If an unprejudiced person, one who had the ability to reason in such matters, were asked what effect the sun's rays should have upon a ring so placed, his reply would be, that matter placed in a circle round the earth should have, in all its parts, optical relations, identical with those of the moon when occupying corresponding positions. Thus, the part of the ring in opposition to the sun, should shine with the greatest brightness; the parts in quadrature with the sun, with half the brightness, &c. The brightest part should be nearest the zenith at midnight. The reverend gentleman makes no mention of such an appearance. His observations, therefore, do not conform to the requirements of his hypothesis.

Von Humboldt, in commenting upon the Rev. George Jones's paper, says he has observed the same phenomenon, *i. e.*, the zodiacal light in the east, as well as in the west, after sunset. He noticed that the two lights disappeared at the same time, and ascribed the cause of the phenomenon in the east to reflection.*

I would fain believe that the objections I have urged to the hypotheses hitherto offered, to explain the cause of this interesting phenomenon, do not apply to the theory here deduced from independent data.

The form and position which the laws of perspective give to the ascending mass of ether, conform to those which observation has given to the zodiacal light, even to the minute point of the greater portion being north of the ecliptic.

The changes in the velocity, &c., of the many minor currents which make up the great hollow cone, depending as they must, upon the varying conditions of the sun's surface, explain the changes which the zodiacal light presents from day to day.

* Comptes Rendus, October 22, 1855.

ETHER. ITS RELATIONS TO COMETS.

After the decline of the Peripatetic school of philosophy, few of the grand operations of nature were ascribed to the agency of ether. The chief additions to its role prior to the present century, were made by Huyghens and Sir Isaac Newton; the former giving to ether a no less important function than the transmission of light, and the latter explaining by its action, one of the phenomena of comets, still held by most astronomers to be a profound mystery of nature.

The views of Sir Isaac Newton on the influence of ether upon the tails of comets, may be found in Book iii, Prop. xli, of the Principia. They accord with the theory I am endeavoring to explain, and are not the less interesting because of his failure to impress the truth of his views upon the scientific world. He says, "Kepler ascribes the ascent of the tails of the comets to the atmospheres of their heads; and the direction towards the parts opposite to the sun, to the action of the rays of light, carrying along with them the matter of the comets' tails; and, without any great incongruity, we may suppose that in so free spaces, so fine a matter as that of the ether may yield to the action of the rays of the sun's light, though those rays are not able sensibly to move the gross substances in our parts, which are clogged with so palpable a resistance."

"Another author thinks that there may be a sort of particles of matter endowed with a principle of levity, as well as others are with a power of gravity; and that the matter of the tails of comets may be of the former sort, and that its ascent from the sun may be owing to its levity; but, considering that the gravity of terrestrial bodies is as the matter of the bodies, and therefore can be neither more nor less in the same quantity of matter, *I am inclined to believe, that this ascent may rather proceed from the rarefaction of the matter of the comets' tails.*"

"The ascent of smoke in a chimney is owing to the impulse of the air with which it is entangled. The air rarefied by heat ascends, because its specific gravity is diminished, and in its ascent carries along with it the smoke with which it is engaged; and why may not the tail of a comet rise from the sun after the same manner? For the sun's rays do not act upon the mediums which they pervade, otherwise than by reflection and refraction; and those reflecting particles heated by this action, heat the matter of the ether, which is involved with them. This matter is rarefied by the heat which it acquires, and because by this rarefaction the specific gravity with which it tended towards the sun before, is diminished, it will ascend therefrom, and carry along with it the reflecting particles of which the tail of the comet is composed."

I have made this quotation from the Principia, because I find that M. Arago, from a

too partial, has given an incorrect version of Sir Isaac Newton's views upon the subject of comets' tails.*

We may easily pardon in the author of the *corpuscular theory of light*, his qualified indorsement of Kepler's theory of comets' tails. The true views of Newton upon this subject were undoubtedly those described in the last part of the quotation from the Principia.

It is certainly a subject entitled to consideration, why so ingenious and plausible a theory should have met with such slender success. There are probably several reasons. Firstly, the existence of any fluid in the interplanetary spaces, was all conjecture. Secondly, those men who believed in the existence of an ether, had their minds so imbued with the notions of the ancients upon the subject, that they could not admit its being possessed of sufficient materiality to direct the tail of a comet. Lastly, the minds of the astronomers of the present century have probably been confirmed in their opposition to the Newtonian theory, by the appearance of the comet of 1823, and of others, with their tails directed towards the sun.

My own belief is, that the usual direction of the tails of comets is occasioned by a cause similar to that which gives to the flame of a candle a direction away from the earth, viz., that the specific gravity of the matter of the tail is less than that of the surrounding ether, and thus, by external pressure, the heated mass is forced away from the centre of attraction.

I hope, by the aid of discoveries made since Newton's day, to explain satisfactorily the cause of a different direction in the few exceptional cases which have been observed.

The next phenomenon of comets I have to mention, which has been ascribed to the influence of ether, is the one upon which this essay is founded,—the discovery of Professor Encke.

"On comparing the intervals between the successive perihelion passages of Encke's comet, after allowing, in the most careful and exact manner, for all the disturbances due to the action of the planets, a very singular fact has come to light, viz., that the periods are continually diminishing, or, in other words, the mean distance from the sun, or the major axis of the ellipse, dwindling by slow and regular degrees, at the rate of about 0.11 days per revolution. This is evidently the effect which would be produced by resistance experienced by the comet from a very rare ethereal medium pervading the regions in which it moves; for such resistance, by diminishing its actual velocity, would diminish also its centrifugal force, and thus give the sun more power to draw it nearer. Accordingly, this is the solution proposed by Encke, and at present generally received."†

This point in the history of comets is of more importance than any other connected with the subject, as all deductions concerning the existence of ether are based upon it.

* Astronomie Populaire, vol. ii, p. 411.

† Herschel's Outlines, chapter xi.

Another phenomenon of comets, which has exercised the ingenuity of astronomers, and one for which an explanation has been sought in ethereal influence, is the fact that, as they approach the sun, their bulk becomes diminished, and increases after passing the perihelion.

If comets were elastic bodies, expansible by heat, and not exposed to any varying pressure, these phenomena are the reverse of what *à priori* reasoning should lead us to expect.

The explanation referred to is the result of the labors of M. Valz, whose theory is thus noticed by M. Arago.

"To explain these changes of volume, M. Valz supposes that the ethereal substance forms round the sun a true atmosphere, that, as in the terrestrial envelope, the lower strata are condensed in proportion to the quantity of the superincumbent medium. He believes that in passing through these regions, the comet must be exposed to a pressure proportioned to the density of the strata. There would be no difficulty here, if we could admit that the exterior envelope of the nebulosity was not permeable to the ether supposed to pervade the universe."

"Everybody knows that a bladder filled with air at the base of a mountain, swells if it be transported towards the summit, and that it will burst if it be taken to a sufficient height. But, where shall we find the pellicle to assimilate the nebulosity to a bladder, which would prevent the ether from penetrating it in every direction, and invading its smallest ramifications?"

"This difficulty for the present seems insurmountable, and we deeply regret it, for the ingenious hypothesis of M. Valz has furnished him with the law of the variations in volume of the nebulosity, as well for the comet of short period, as for that of 1618, with an exactitude truly extraordinary."*

Sir John Herschel makes the following remarks upon the proposed explanation:

"M. Valz, who was the first to notice this fact (in Encke's comet), accounts for it by supposing it to undergo a real compression or condensation of volume, arising from the pressure of an ethereal medium, which he conceives to grow more dense in the sun's neighborhood. But such a hypothesis is evidently inadmissible, since it would require us to assume the exterior of the comet to be in the nature of a skin or bag impervious to the compressing medium."

"The phenomenon is analogous to the increase of dimension above described, as observed in the comet of Halley, when in the act of receding from the sun, and is doubtless referable to a similar cause, viz., the alternate conversion of evaporable matter into the states of visible cloud, and invisible gas, by the alternate action of cold and heat."†

Is not this a melancholy confession for men of the standing of M. Arago and Sir John

* Astronomie Populaire, vol. ii, p. 391.

† Outlines of Astronomy, chapter xi.

Herschel? The observations, the calculations, the successful result of the labors of M. Valz to be put aside, because they, though living in the nineteenth century, were, in the matter of ether, wedded to the doctrine of the ancients. *The comet would want a skin.* Most justly did Bacon classify among the causes of error the *Idols of the Theatre.*

Let me endeavor to draw a parallel which may shed some light upon this cometary phenomenon. Suppose a given bulk of our atmosphere, containing a cloud, to be brought from the region of the cumuli to the surface of the earth. Now a cloud like a comet has no skin; yet, does any one doubt that (neglecting the changes produced by heat) the cloud would, by varying its position, be reduced in volume in the same proportion as the air in which it was suspended?

The theory of M. Valz was based upon data furnished by the observations and deductions of Encke, viz., the existence of a fluid in space having inertia. Being possessed of inertia, it would be most unphilosophical to believe it wanting in the other properties of matter, especially those of the aeriform bodies. His explanation was, in my opinion, a masterpiece of reasoning.

The three phenomena of comets I have now spoken of, and which have been by different astronomers ascribed to the influence of ether, are features which are believed to characterize comets as a class; they constitute a rule which applies to all these bodies.

It is true, some of the greatest lights which adorn the science of astronomy, disbelieve in the connection between ether and these phenomena. This slowness to receive new ideas, has characterized eminent men in all ages, and persons of the greatest learning, whose efforts have been most availing, in the advancement of astronomy, have died in utter unbelief in doctrines, in which their contemporaries and immediate successors have placed general and implicit credence.

Tycho Brahe, who, during his whole life, had the benefit of the truths contained in the great work of Copernicus "De Revolutionibus," believed in the immobility of the earth, and in the daily revolution of the sun and planets round the same.

What is more remarkable still, these views were held by the expounder of the inductive philosophy.* If anything could shake our confidence in the value of Bacon's exclusive system, it is the fact, that with the truth before him, his inductive philosophy failed to prevent him from believing in error.

I shall now draw attention to two cometary phenomena which, unlike the three already spoken of, are exceptional. I am not aware that any attempt to explain them has ever been made; but if the ether with its circulation through the solar system exists, as it is the purpose of this paper to describe, the explanation of both will be simple and satisfactory.

* See Bacon's essay "On the Ebb and Flow of the Sea."

The comet which, during the last century and a half, has, more than any other, given rise to the speculation, the calculation, the wonder, and the triumph of astronomers, is unquestionably that of Halley.

The comet in question furnishes us with a single known exception to the law, that as comets approach the sun the splendor of their tails increases, and after passing their perihelia gradually diminishes to their final disappearance.

History records eight different visits of Halley's comet to its perihelion, from the year 1305 to 1835 inclusive.

The inclination of this comet to the ecliptic is less than eighteen degrees, and its perihelion distance about half the radius of the earth's orbit. The comet, while approaching and receding from its perihelion, must, therefore, have passed through that part of the solar system where the ascending current of ether exists in greatest force.

If the ethereal current have any power to detach the tail of a comet from its nucleus, by the force of its blast, we might suppose it should be conspicuously displayed upon Halley's comet.

During five of the visits of Halley's comet to its perihelion, we have the testimony of the contemporary astronomers that the tail diminished or disappeared on approaching the sun, or that it reappeared and expanded after passing the nearest point to that orb. Sir John Herschel, in the year 1835, recorded both of these phenomena.*

* Halley's comet passed its perihelion June 8th, A. D. 1456. I extract from "Pingré's Cométographie" the following notices of this visit of the comet:

"Although two Polish historians assure us that the size of this comet had not appeared great in Poland, all others agree in representing it as grand, terrible, of an extraordinary size, and carrying in its train a tail which covered two signs, or sixty degrees."

"This tail, however, was not always of the same length: it was observed of thirty spans; it was observed of more than one hundred spans; sometimes no trace of a tail could be seen." (Vol. i, p. 459.)

The 6th June the length of the tail was twenty-two degrees. (p. 461.)

"Another contemporary historian says, the 3d June, the tail was ten degrees, as he satisfied himself with instruments." (p. 461.)

"At Bologna, in Italy, where the latitude is 44° 30′, the comet set, but for a short time, its tail, moreover, after having entirely disappeared, was about to reappear. Ne devait pas tarder à reparaitre." (p. 462.)

In 1531 Halley's comet passed its perihelion August 24th. Pingré says, "The most valuable observations we have of the comet of 1531, are those of Apian, the astronomer of the Emperors Charles V, and Ferdinand I. He began his observations the 13th August. He noticed that in general the tail was opposite the sun, and that it disappeared when the comet approached the horizon, so that he thought at first that a cloud obscured the view." (Vol. i, p. 487.)

Inasmuch as the tails of comets become brighter on approaching the horizon in their diurnal motion, owing to the increasing darkness, I conclude that the astronomer Apian must have referred to the comet's orbital motion, which is equivalent to saying that as the comet approached the sun, its tail disappeared.

I am now about to discuss the last of the cometary phenomena which I think admits of explanation by the influence of ether.

When endeavoring by the aid of *à priori* reasoning to trace out the course of the grand ethereal currents which circulate through the solar system, I pointed out the necessity for the existence of two currents of ether, which should descend upon the sun's polar regions; and hinted that analogy justified the belief that the polar currents descend upon the sun's surface in the form of vortices.

An interesting question naturally associates itself with these views, viz. What effect should be produced upon a comet which passed through the regions where these currents prevail?

We will suppose the comet before entering the region to present the normal features of these bodies. If it be furnished with a tail, we will suppose that it is pointed in the direction away from the sun.

Passing into the vortex, the head of the comet should undoubtedly feel the effect of the downward current before the distant portions of the tail. We might, therefore, expect to see the old tail, while pursuing its trajectory, gradually leave the head, and a new tail, entangled by the descending current of ether, carried in a direction obliquely towards the sun.

In 1607 Halley's comet passed its perihelion October 26th. "The tail was visible from the time the comet was first perceived by Kepler, on the 16th September, until the 12th of the following month." (Hind, Comets, p. 36.)

In 1759 Halley's comet passed its perihelion March 12th. Pingré says, "La Nux did not content himself with observing the nucleus; he was attentive also in measuring the length of the tail. He found it on the 21st April, 8 degrees; the 28th April, 25 degrees; May 1st, 33 to 34 degrees; May 5th, 47 degrees. It lessened afterwards. May 14th, it was only 19 degrees." (Cométographie, vol. ii, p. 65.)

In 1835 Halley's comet passed its perihelion November 15th. Sir John Herschel says: "It was not before the 2d October that the tail began to be developed, and thenceforth increased pretty rapidly, being already 4° or 5° long on the 5th."

"It attained its greatest length (about 20°) on the 15th October. From that time, though not yet arrived at its perihelion, it decreased with such rapidity that already, on the 29th, it was only 3°, and on November 5th, 2½° in length. There is every reason to believe that before the perihelion, the tail had altogether disappeared, as, though it continued to be observed at Pulkowa up to the very day of its perihelion passage, no mention whatever is made of any tail being seen."

"Professor Struve says, the nucleus appeared like a stream of fire which issues from the cannon's mouth after discharge, when the sparks are driven back by a violent wind." (Hind, p. 48.)

"As the comet receded from the sun, the coma speedily disappeared, as if absorbed into the disc, which, on the other hand, increased continually in dimension. . . . While this increase of dimension proceeded, the form of the disc passed, by gradual and successive additions to its length, in the direction opposite to the sun, to that of a paraboloid. . . . It is evident that had this process continued with sufficient light to render the result visible, a tail would have been ultimately reproduced, but the increase of dimension being accompanied with diminution of brightness, a short, imperfect, and, as it were, rudimentary tail only, was formed, visible as such, for a few nights,

After passing through, and out of the downward current, we should expect to see the new tail separate from the head, and another appendage restored in the normal direction.

On examining the catalogue of comets in Mr. Hind's "Descriptive Treatise," I find in the present century only four, the inclination of whose orbits was more than seventy degrees, and whose perihelion distance was less than one-fourth of the radius of the earth's orbit.

Of these four comets, it is recorded of three that they had *double tails.*

The first is that of 1823, the inclination of whose orbit was 76° 11′ 57″, and whose perihelion distance was 0.22650. The following interesting account of its remarkable appearance is furnished by M. Arago.

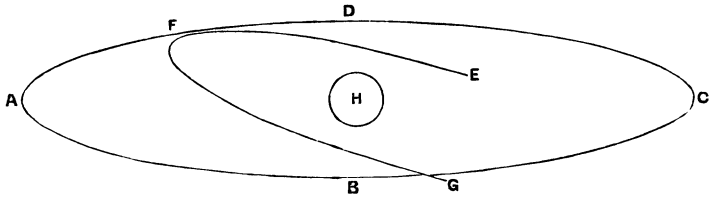
"The comet of 1823 (No. 140 of the catalogue) had two tails, and, strange, while one, as is usual, was pointed away from the sun, the other was turned towards that luminary, which gave it a resemblance to the nebula in Andromeda."

"On the 23d January, 1824, the ordinary tail seemed to be 5° long, the length of the

to the naked eye, or in a low magnifying telescope, and that only when the comet itself had begun to fade away by reason of its increasing distance." (Herschel's Outlines, chapter xi.)

ORBIT OF HALLEY'S COMET.

FIG. 4.

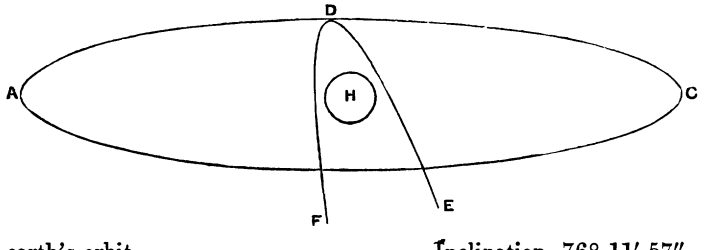


A B C D, The earth's orbit.
E F G, The comet's orbit.
H, The sun.

Inclination, 17° 45′ 5″.
Perihelion distance, 0.58657.
Longitude of perihelion, 304° 31′ 32″.
Longitude of ascending node, 55° 9′ 59″.

ORBIT OF THE COMET OF 1823.

FIG. 5.



A B C D, The earth's orbit.
E D F, The comet's orbit.
H, The sun.

Inclination, 76° 11′ 57″.
Perihelion distance, 0.22650.
Longitude of perihelion, 274° 34′ 30″.
Longitude of ascending node, 303° 3′ 0″.

other was scarcely 4°; their axes formed together a very obtuse angle of 160°. Near the comet the abnormal tail could scarcely be seen; its brightest point was 2° from the nucleus. In the early days of February, the tail opposite the sun could alone be seen; the other had disappeared, or had become so feeble that the best night glasses, in clear weather, gave no trace of it. These results are a summary of observations made at Paris, Marseilles, Marlia, Bremen, Gottingen, and Prague. No comet had up to that time presented so extraordinary an appearance."*

The second comet of this class was that of 1825. The inclination of its orbit was 89° 22′ 10″, and its perihelion distance 0.02689. M. Arago gives the following account of it.

"The tail of the comet of 1825 (No. 145 of the catalogue), observed in New Holland by Mr Dunlop, consisted of six distinct branches of different lengths. On the 19th October, the rays proceeding from the tails on the extremes, seemed to cross behind the comet like rays which diverge from the focus of a lens. On the 1st November, we find in Mr. Dunlop's account expressions not less explicit. At one degree and a half from the head, rays from the different tails diverge indefinitely, in such a way that the rays forming the right border of the tail come from the left of the head, and reciprocally."†

It would not be easy to describe more precisely the probable effect upon a comet's tail of being caught in a vortex of ether.

The last comet of this class was the fourth comet of 1851, discovered by M. Brorsen. The inclination of its orbit was 73° 59′ 44″. Its perihelion distance was 0.14132.

It is No. 193 of M. Arago's catalogue, who states "that it had two unequal tails, of which the shorter was directed towards the sun."‡

We have it recorded of many comets, as was the case with Halley's in 1835, that a ray of light was ejected from the anterior surface of the nucleus, which finally became involved with the tail; but no other comets seen in the present century have exhibited the appearance of those just described.

ETHER. ITS RELATIONS TO THE SEASONS.

The subject of ether in its bearings upon the zodiacal light and comets, is one which interests alone the man of science; if it can be shown, however, that the amount of heat which our planet receives from the sun, is supplied partly by the agency of ether, and if the periods when these accessions of caloric are likely to occur, can be pointed out, the subject increases in importance, and the agriculturist, the physician, and, indeed, the world at large, will share with the astronomer the interest which the subject inspires.

In my efforts to trace out the course of the grand ethereal circulation, I arrived at the conclusion that the ascending current has nearly the form of a plate whose sides decline a

* Astronomie Populaire, vol. ii, p. 407. † Id., p. 408. ‡ Id., p. 408.

little from the plane of the sun's equator, so as to give it the character of a hollow cone, the sun's centre occupying the apex of the cone.

The fact of the zodiacal light being seen more than ninety degrees from the sun, I respectfully submit, may now be adduced as evidence that the current extends beyond the earth's orbit.

If there be reality in the conditions I have endeavored to portray, it follows that our planet must, twice in every revolution round the sun, pass through the ascending current of ether; and if, at the distance of the earth's orbit from the sun, the current retain a portion of heat above that of the surrounding medium, we should, while passing through the mass, look for an increase of temperature in all parts of the globe, where special causes do not affect the climate too forcibly to permit the influence of the ether to be observed.

In order that the temperature of our planet should be affected by that of the surrounding medium, it is not necessary that the temperature of space should, by any means equal that of the coldest part of the earth; and for the following reasons. All bodies radiate heat to the objects and the space in their vicinity, and the amount of caloric which any body loses by radiation, is dependent in a measure upon the capacity for receiving heat possessed by the bodies in its vicinity. Thus, if while passing through the ascending current of ether, the earth lose a less amount of heat by radiation than in other parts of its orbit, a larger portion will remain to affect our senses.

The exact position and direction of the ascending current becomes a subject of absorbing interest. The only data we possess for determining these points are the causes believed to be concerned in its origin and propagation. We are, therefore, forced to pursue the *à priori* system of reasoning.

As has been already stated, the ascending current of ether takes its origin from a vast zone of the sun's surface, extending many degrees on each side of the equator, the larger portion being to the north of that circle.

If the equator divided this zone into equal parts, and if, indeed, the maximum heat of the sun's surface were on the line of the equator, then a very simple course of reasoning would teach us that our planet must pass through the heated mass at the points of its orbit intersected by the plane of the solar equator. We should, therefore, look for seasons of warmth about the sixth days of June and December.

Inasmuch, however, as the sun's northern hemisphere is hotter than the southern, and as the line of maximum heat lies 1° 29′ 6″ north of the equator, the problem becomes less simple; highly interesting complications are developed, and we find our attention drawn to a subject which, as far as men's published thoughts go, is a new field of research.

Before progressing further in this investigation, it is indispensable to call to mind the precise relations of the sun's equator to the ecliptic. It is inclined, according to M. Arago,

about seven degrees. The declination of the north pole of the sun from that of the ecliptic, is in the direction of longitude 345°. The earth passes through the point of its orbit corresponding in longitude on the 8th September.

If the declination of the ethereal current from the plane of the sun's equator equalled the inclination of the latter to the ecliptic, viz., 7°, the earth would encounter the mass at only one point in its orbit, at D.* (See Plate I, fig. 6.)

The declination being less than 7°, the earth must meet the heated mass at two points, the one between B and D, and the other between D and F.

We have now to consider another element which influences the direction as well as the position of the ascending mass, viz., the motion given to the columns by the sun's axial rotation.

If, after leaving the solar surface, the columns retained a tendency to move in circles round the sun's axis, we should infer that the points where the earth traversed the mass were equidistant from longitude 345°.

But, inasmuch as the columns of ether should, after leaving the sun, be impelled in tangents to the circles they revolved in while upon the sun's surface, a different solution to the problem must be found.

To this point I have given much reflection, and am firmly of the belief that a translatory motion of the ethereal columns in the direction of an increase of longitude, should bring the ethereal mass into contact with the earth's orbit at two points whose mean is more advanced in longitude than 345°.

We have, therefore, to look for two periods of warmth between the months of June and December, produced independently of the sun's declination, or any other cause to which changes of the seasons have been heretofore ascribed.

* The circle H, in the centre of the figure, is the sun, which, for convenience of demonstration, we will suppose surrounded at the distance of the earth's orbit by an imaginary sphere, represented by the outer circle.

A B C D E F G, is the earth's orbit, seen obliquely.

I G B K F, is the solar equator projected upon the imaginary sphere.

L C M E, is a small circle projected upon the imaginary sphere, showing where the ethereal current passes through it.

The curved lines within the circle, are the columns of ether passing through the interplanetary space.

The point A is in longitude 165°, and D in 345°. The latter is the direction towards which the sun's north pole is inclined seven degrees.

The earth is at A, on the 6th March; at B, on the 6th June; at D, on the 8th September; and at F, on the 6th December.

At C, the earth's orbit intersects the ethereal cone, the planet (by theory) passes that point on the 10th August; the epoch of the mean of the canicular days.

At E the orbit again intersects the cone of ether, the planet passes that point theoretically on the 12th November, the epoch of the mean day of the Indian summer.

The mean day of the interval separating these seasons of warmth, must be more advanced in the year than the 8th September.

Have such seasons been observed?

Have names been assigned to them?

Since the earliest days of civilization, it has been known that the greatest heat of summer does not coincide with the summer solstice. The ancient Egyptians, noticing that certain days, remarkable for sultry heat, occurred about the beginning of July, at which time the dog star emerged from the sun's rays, gave the name of the star to the season, which is generally known as the canicular, or dog days. According to the almanacs, they are reckoned about forty, beginning on the 3d July, and ending the 11th August. This was doubtless true in the days of the Pharaohs, but, at the present time, the canicular days are correctly estimated by M. Bescherelle to begin about the 24th July, and end the 26th August.

Mr. Brande says, "Owing to the precession of the equinoxes, the heliacal rising of Sirius now takes place later in the year, and in a cooler season; so that the *dog days* have not now that relation to the particular position of the *dog star*, from which they obtained their name."

In this I must disagree with Mr. Brande. The dog days still bear their old relation to the rising of the dog star.

Astronomers have not yet discovered that the sun's axis undergoes any change in position, though theoretically it must from planetary influence, revolve about the pole of the ecliptic, just as the earth's axis does, but in an inconceivably long period. We may, therefore, consider the sun's axis as firmly fixed as the place of Sirius, and look for a continuance of the occurrence of the dog days with the heliacal rising of Sirius.

Besides the heat and sultriness which characterize the dog days, there is another feature which is a very usual attendant, viz., an obscurity in the atmosphere which does not appear to be associated with moisture, smoke, or dust. It sometimes comes on so rapidly that, in the course of four or five hours, a whole landscape, as far as the eye can see in every direction, is affected by it. I have known this state of things to continue six days at a time, in spite of the intervention of a strong wind and rain.

It may possibly never be determined what the origin of this obscurity is. I will observe, however, that it is a part of this theory of ethereal currents that, during the dog days, our planet is passing through the substance of the zodiacal light.

The only explanation of the cause of the canicular days, I have ever heard of, is that of the Egyptians; viz., the malignant influence of the dog star.

If M. Bescherelle be correct in his estimate of the number, and time of occurrence of the dog days, viz., from the 24th July to the 26th August inclusive, their number is thirty-four, and the morning of the 10th August is the period of their greatest intensity.

After passing through the heated stratum, our planet is, for a few weeks, on the north side of the mass, or inside the ethereal cone. (See Plate I, fig. 6.)

During this time the autumnal equinox occurs. The declining power of the sun, and increasing length of the nights, seem to produce a rapid advance toward winter. But the earth soon approaches and enters the ethereal mass the second time in the year, and the progress of winter seems stayed. Again our atmosphere is obscured, the sun's disc looks red, and the mornings and evenings seem to rival the noontide in warmth. These phenomena appear the more striking, because they often take place after the occurrence of frosts.

This delightful season is known over the North American continent, from New England to California, and from Canada to Mexico. In the United States and Canada it is called the "Indian Summer," and in Mexico, "Veranillo de San Martin,"* the little summer of St. Martin.

The name of Indian summer was probably given to it by the English colonists, because the season being unknown in the British islands, they supposed it to be peculiar to their new home. The Mexican name is the one used in Spain.

It is known in France as "L'été de St. Martin," and in Southern Europe by names of similar import.

In Germany it is called "Alter Weiber Sommer" (old woman's summer). In Russia, "Babie Leto;"† meaning the same as the last. In Sweden, "Efter Sommarn,"‡ the after summer.

At Rio Janeiro, at the time of the year when the Indian summer prevails in the northern hemisphere, the atmosphere has the obscurity which characterizes the season.§

The Indian summer does not make its appearance on a fixed day in the year, its approach (in America) is gradual. Some days possessing its features are generally observed in the end of October; they occur at intervals, and in periods of varying duration through November, and the influence of the season is sometimes felt in the early part of December.

The burning of the grass on the prairies by the Indians in North America, has been given as the cause of the warm weather and obscured atmosphere of this season. The phenomena being observed in Europe, is a sufficient refutation of the hypothesis.

The name given to the season in the south of Europe, and in Mexico, is perhaps the best indication of the period of its greatest intensity.

The feast of St. Martin is celebrated on the 11th November.

Thus, we find that in the time of the occurrence of the canicular days, as well as of the

* Señor Felix Merino, Consul, Philadelphia.

† Comte de Bouxhoevden, Russian Army.

‡ Mr. Carl Arfwedson, Stockholm.

§ Dr. Charles Eversfield, U. S. Navy.

Indian summer, popular observation has supplied us with data which the notes of astronomers have failed to furnish.

There are some parts of the world where the force of special causes is such as to prevent the Indian summer from being felt. In the British islands the climate is, in a great measure, determined by the influence of the Gulf Stream. On the coast of California the Indian summer is not known, probably from the existence of the *Kuro Siwo*,* or *Japan Stream*, a current in the Pacific Ocean, having geographical analogies with the Gulf Stream.

In the polar regions of the earth, the influence of the sun's rays in producing heat, is at its minimum, while any effect derived from the medium by which our planet is surrounded, is, except in special cases, equally displayed in all parts of the earth.

Any depression in temperature, owing to ethereal influence, must be most perceptible in the polar regions, because there the other cause of heat is at its minimum.

In the month of March our planet attains its extreme distance from the ascending current, we should, therefore, look for the greatest degree of cold in the polar regions in that month.

Dr. E. K. Kane, during the winters of 1853–4 and 1854–5, spent in lat. 78° 37′, on board the brig Advance, found the coldest weather in the month of March.†

Dr. I. I. Hayes, who was surgeon to the expedition under Dr. Kane, confirms his report of the temperature of the weather in March.

Dr. Hayes also passed the winter of 1860–61 on board the schooner United States in lat. 78° 17′. The coldest weather of that year occurred in the month of March.‡

According to this observer, such is the uniform experience of Arctic navigators.

Even in the temperate regions of the earth, the month of March is a most boisterous season. One of its peculiar features is a chilling atmosphere, accompanied by considerable power in the sun's rays. It is said to "come in like a lion, and go out like a lamb;" an order of events to which not only the obliquity of the ecliptic, but also the relation of the sun's equator to the earth's orbit, eminently conduces.

At the opposite season of the year, in the month of September, the earth reaches its extreme distance from the ethereal current, for that half of the year.

From the relation of the ethereal current to the solar equator, the earth does not then attain the same distance from the heated mass as in the month of March. We cannot expect, therefore, to find the same degree of cold exhibited in September as in March. And such is common experience.

* See "A paper on the Kuro Siwo, or Japan Stream." Read before the American Geographical and Statistical Society by Silas Bent, Lieutenant U. S. Navy. New York, January 24th, 1856.

† In a private conversation.

‡ In a narrative delivered to the Academy of Natural Sciences, Philadelphia, November 26th, 1861.

Our theory teaches us that ethereal influence causes two maxima of heat in a year, occurring in the months of August and November; also a maximum of cold in the month of March, and a lesser degree of cold in September.

The first three phenomena are of sufficient intensity to be distinctly evident to our senses.

The object of this paper is to point out the periods when accessions of heat and the occurrence of cold from ethereal influence are likely to take place; not to limit the time when they are possible.

As the sun's equator is only inclined by seven degrees to the ecliptic, it is not likely that any part of the earth's orbit is wholly beyond the influence of the ascending mass of ether.

I have certainly observed in the months of February and April, days in which the redness of the sun, the warmth and peculiar opacity of the air, called to mind the features of the Indian summer.

In discussing the question of the possible influence of comets upon our planet, M. Arago mentions the occurrence, on two occasions, of the phenomenon of dry fogs. The first was in the year 1783, began on the 18th June, was observed over the whole globe at the same time, and lasted more than a month.*

The second, occurred in the year 1831. It was observed first on the coast of Africa, August 3d; at Odessa, August 9th; in France, August, 10th; in New York, August 15th; in China, the end of August.

With regard to the fog of 1783, M. Arago mentions two explanations proposed by Franklin. 1st. The dissemination by winds of the smoke of Mount Hecla, which was in eruption during the whole summer. 2d. The imperfect combustion in our atmosphere of an immense meteor.

Any one having faith in the theory I have endeavored to establish, on noticing the time of the year when the dry fog of 1831 occurred, would certainly ascribe it to a cause identical with that which produces the opacity in the air during the continuance of the dog days.

The proposed combustion of the meteor in our atmosphere, seems to me a weak point in Franklin's hypothesis, because, if a combustion had occurred of sufficient magnitude to fill the whole earth with its smoke, it is remarkable that the light and other results of combustion were not observed.

My own belief is, that in both instances the obscurity was caused by an emanation from the sun, transported to the earth by the ascending current of ether, and the phenomena were closely allied in character to the seasons of warmth known as the dog days, and the Indian summer.

* Astronomie Populaire, vol. ii, chap. 36.

ETHER. ITS RELATIONS TO PERIODICAL SHOOTING STARS.

With the seasons of warmth, whose causes I have endeavored to determine, there seems to be allied by a nice coincidence in time, a phenomenon of a very different character. I refer to periodical shooting stars.

The first of these phenomena in the order of the year, appears on or about the 10th August, a time which corresponds exactly with the mean occurrence of the dog days.

The other exhibition is observed on the 12th November, and to show the closeness of the coincidence in time with the Indian summer, we may call to mind that this season in the south of Europe is known as the summer of St. Martin; the festival of which saint is celebrated on the 11th November.

Shooting stars being one of the most beautiful and striking features of night, men have, in all ages, made their origin and nature a subject of speculation.

An intelligent compiler has classified the various explanations offered upon the subject, into the following five hypotheses: the atmospheric; the volcanic; the planetary; the lunar; and the nebular.*

This classification is imperfect, as it does not include Professor Olmstead's scheme of a nebula revolving round the sun once in six months, and meeting the earth on the 12th November;† nor that adopted by Sir John Herschel, in which a broken stream or annulus of meteors is encountered by the earth in a certain part of its orbit: the breaks in the annulus corresponding with the omissions of the exhibition.

I stated my objection to Professor Olmstead's hypothesis when treating of the zodiacal light, in its requiring a precise coincidence in the periodic time of two bodies moving independently of each other.

The explanation of the broken stream of meteors has received the support of many of the most distinguished savants of Europe, among others, of Poisson, Arago, and Von Humboldt. It is bold, and to my view arbitrary, as it has no analogies with known astronomical facts to give it probability; nor is any other phenomenon of nature explained by it. It appears, too, that this hypothesis does not exhibit that ingenuity which we look for in a scheme supported by such distinguished men, for Sir John Herschel says: "We need not suppose the meteoric ring coincident in its plane with the ecliptic."‡ This debars its defenders of the ability to account for more than one exhibition in a year, unless they occurred at precisely opposite seasons.

* Lardner's Lectures on Science and Art, vol. i, p. 461.

† American Journal of Science and Art, vol. xxix, p. 376.

‡ Outlines of Astronomy, chapter xvii.

The explanation is a graft induced by the periodicity of the phenomenon upon the theory of Chladni.* It is a mere addition, however, not an improvement.

The two grandest exhibitions of shooting stars recorded in modern times, occurred on the night of the 12th November, in the years 1799 and 1833. Many observers claim to have seen wonderful displays of the phenomenon on other anniversaries of the 12th November. The belief is strong, however, among astronomers, that the displays of 1799 and 1833, were incomparably superior to those of any other years.

Olbers, the celebrated physician and astronomer of Bremen, suspected that these grand exhibitions would only occur at intervals of thirty-four years.†

Von Humboldt says, "The acute mind of Olbers led him almost to predict that the next appearance of the phenomenon of shooting stars and fire-balls intermixed, falling like flakes of snow, would not recur until between the 12th and 14th November, 1867.‡

It would have been prudent in the philosopher of Bremen to have given the world the data upon which his prediction was founded. If his only ground for making it were, that the time which had elapsed between 1799 and 1833, when added to the latter date, will bring us to 1867, we can award him but a slender meed of praise. A man of less ability might have made a surmise as likely to prove correct.

The explanation which I am about to offer for the phenomenon of periodical shooting stars, is a part of the grand scheme of ethereal currents. Up to this time, I have asked for the admission of no new astronomical condition, without accompanying it with independent evidence of its existence. This constitutes the scheme a theory. I shall now be obliged to bring forward one or two points which are hypothetical, but I trust the remarkable numerical coincidence which I shall adduce in support of these points will lead to their adoption.

Experiments made with the spectroscope by Messrs. Bunsen and Kirchoff, upon the flames of various combustible metals, and a comparison of the resulting phenomena with the dark lines of the solar spectrum, have led them to the conclusion, that the sun consists of an ignited solid or liquid central body, throwing off white light, and an atmosphere containing iron, sodium, lithium, and other metals in a vaporous state, yet capable of absorbing parts of the white light.§

Upon these positive results, I now postulate that a portion of the metals in the solar atmosphere escape from the sun without undergoing the chemical change which produces the light and heat; that the portions of the sun's surface from which these metals escape are limited in number and small in extent; that the vaporous metals are, by the ascend-

* Milner, Gallery of Nature, p. 137. † Astronomie Populaire, vol. iv, p. 329.. ‡ Cosmos, vol. i, p. 127.

§ London, Edinburgh, and Dublin Philosophical Magazine, or Journal of Chemical Society, London, 1861 and 1862.

ing current of ether, carried to the region of the planets; that the stream of metallic vapor* reaching the earth's orbit, at the time and place where the planet is passing, will be ignited by its atmosphere, and produce the phenomenon of a shower of shooting stars; and lastly, that the stream which produced the meteors of November 12th, in the years 1799 and 1833, issued from one and the same spot upon the sun's surface.

An encounter between the metallic stream and the earth, can only occur at two points in its orbit, viz., where it passes through the centre of the ethereal current. Our experience with the seasons has determined these epochs to be the 10th August, and about the 11th November. The incident can only take place at those times, when the portion of the sun's surface which emits the metallic stream is favorably situated to produce an encounter with the earth.

A candid listener, on hearing this proposition, would, in view of the overwhelming odds against finding a coincidence, be apt to exclaim, "We will grant your postulates, if you can show the existence of a *cycle of solar rotation* coinciding with thirty-four orbital revolutions of the earth."

Unpromising as the chance of finding the required coincidence may appear, it nevertheless exists; and is, moreover, one of remarkable exactness.

If we take the number of days in the sidereal year, and multiply it by the interval between the two great exhibitions of shooting stars, and divide the product by the period of the sun's rotation, thus,† $365.256 \times 34 = 12418.704 \div 25.5 = 487.008$, we shall get as a quotient the number 487.

The coincidence may be made more striking by another mode of exhibition:

$$365.256 \times 34 = 12418.704.$$
$$25.5 \times 487 = 12418.5.$$

Thus, we find there is a cycle of solar rotation, in which 487 rotations of the sun correspond in period with 34 revolutions of the earth in its orbit; thus, too, it is proved by the simplest rules of arithmetic, that any part of the sun's surface, turned towards the earth at any given point in its orbit in the year 1799, was also turned towards the earth at the same point in its orbit in the year 1833, and will be again in the years 1867 and 1901.

The difference between the two periods is only two-tenths of a day, or four hours and forty-eight minutes.

* I have used the expression, metallic vapor, for want of a better, to describe the condition of the metals when in the sun's atmosphere, and while being transported by the ethereal current to the earth's orbit.

A metallic vapor, doubtless, it is while in the sun's atmosphere, but the many recorded occurrences of the fall of *meteoric dust*, may give us a clue to the true condition of the metals while making the journey through the planetary spaces.

† Astronomie Populaire, vol. ii, p. 86.

The knowledge of this coincidence lends an interest to the quasi prediction of the intelligent Olbers, which before it wanted; and its fulfilment, should it occur, will certainly give stability to the theory which induced the search for and discovery of the cycle of solar rotation.

Theophanes, one of the Byzantine historians, records that, in November of the year 472, the sky appeared to be on fire over the city of Constantinople, with coruscations of flying meteors.*

Deducting the year 472 from 1799, gives us 1327, which is one year more than 39 cycles of solar rotation. The fact is, therefore, only interesting to us, as it awakens the suspicion that the historian who recorded an event occurring three centuries before his own time, may have erred in the date by a single year.

The considerations which induced me, when investigating the influence of ether upon the seasons, to conclude that the mean day between the dog days and the Indian summer, should be more advanced in the year than the 8th September, have a similar bearing upon the subject of periodical shooting stars.

Between the 10th August and the 12th November, the mean day is the 26th September, which is eighteen days after the 8th September. It is a fair subject of inquiry, What is the significancy of these eighteen days?

Without being able to offer an opinion for which I can furnish a basis, I respectfully submit that, under the influence of the tangential force, acting upon the metallic stream after leaving the sun, the eighteen days represent the time required for the vaporous metals to reach the earth's orbit.

The investigation of the relations between the period of the sun's rotation and the sidereal year, not only teaches us that there is a very great probability of a display of shooting stars on the 12th November, 1867, but further, that there is a lesser probability of a smaller exhibition on the anniversaries of that day in the years 1864 and 1870, and for the following reasons:

The number of days in three years is 1095.795. This is just sixteen hours and fifty-five minutes less than forty-three rotations of the sun.

In a whole cycle of solar rotation, the years which show the greatest probability of a meteoric display, after the termini of the cycle, are the third year before, and the third year after those epochs.

It is not likely that the inhabitants of the countries which witness the displays at the termini of the cycles, will also see those which may occur at the triennial anniversaries; as the longitudes of the places where the three phenomena will be visible are different.

On examining Figure 6, showing the relation between the earth's orbit and the ascend-

* Gallery of Nature, p. 138.

ing current of ether (which, hypothetically, is the great reservoir of meteoric matter), we may draw conclusions regarding the probable frequency of shooting stars in different seasons of the year.

The earth is at A on the 6th March, at B on the 6th June, at C on the 10th August, at D on the 8th September, at E on the 12th November, and at F on the 6th December.

It is evident that while passing from F to B, the planet is more distant from the ethereal current than while performing the other half of its yearly course. Consequently, we should then expect to observe a comparatively small number of shooting stars.

While passing from B to F, the planet is twice carried through the ethereal current, and is at no time far removed from it. The distance is greatest in September.

The richest displays of shooting stars might, therefore, be reasonably expected during the last half of the year.

M. Arago furnishes several very interesting tables connected with observations upon sporadic shooting stars. I have copied below that of MM. Coulvier Gravier and Saigey, which is the mean monthly number of shooting stars seen during the hour which includes midnight.

January,	3.6	July,	7
February,	3.6	August,	8.5
March,	2.7	September,	6.8
April,	3.7	October,	9.1
May,	3.8	November,	9.5
June,	3.2	December,	7.2*

By comparing this table with Figure 6, its agreement with the conclusions drawn from the *à priori* argument is striking.

The circulation in the ether is a process which I have taken the pains to deduce from conditions ascertained by different astronomers for abstract purposes. I have pointed out its influence in the production of the zodiacal light, and shown some new effects upon the tails of comets, and its influence upon the seasons. Taken in connection with the rotation of the sun, and the revolution of the earth in its orbit, I have offered reasons for believing that the ethereal circulation causes the periodicity in shooting stars.

Viewing this process as the result of conditions previously determined, and as the cause of the phenomena I have discussed, its existence may be said to be proved by two systems of reasoning.

I now resign the subject, with the conviction that as it is one of immense interest, and has received no justice at my hands, it will speedily provoke the inquiry of persons who have made special studies of the phenomena which I have endeavored to combine under one cause.

* Astronomie Populaire, vol. iv, p. 289.